Acta Derm Venereol (Stockh) 1998; 78: 201–204

Subbandage Pressure Measurements Comparing a Long-stretch with a Short-stretch Compression Bandage

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Forty-three patients with venous leg ulcers were randomized into treatment with either a long- or a short-stretch compression bandage. Subbandage pressure was regularly measured during rest and walking for a period of up to 1 year. The long-stretch bandage was kept on as long as possible, often up to 1 week. It maintained a significantly higher subbandage pressure in the upright position and during passive dependency as well as during walking than the short-stretch bandage after both 2 and 24 h. The difference between maximum and minimum subbandage pressures during walking did not differ between the two groups. Thus, in contrast to general opinion, the short-stretch bandage did not produce a higher peak working pressure than the long-stretch bandage. The pressure decreased in the supine position in both groups. ***Key words: venous insufficiency; vein-muscle pump; subcutaneous bloodflow.***

(Accepted November 20, 1997.)

Acta Derm Venereol (Stockh) 1998; 78: 201–204.

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Capillary leakage of cells, macromolecules and fluid probably plays a role in the pathogenesis of lipodermatosclerosis and venous ulcer, and it has been suggested that application of an external pressure of 35–40 mmHg in the ankle area is necessary to prohibit the capillary leakage induced by venous and capillary hypertension (1).

Different types of compression bandages with varying degrees of elasticity are used in the treatment of venous insufficiency. The short-stretch bandage is generally believed to have a high ambulatory pressure and a low pressure when the patient is at rest, improving the vein-muscle pump. However, the extravascular diffusion in the skin is probably not normalized, nor the ambulatory pressure within the deep veins, and since patients with venous ulcer are often aged and immobile a high external pressure also during rest might be of importance. This can probably be obtained by using a bandage with high elasticity.

The present study has been performed in order to evaluate the efficacy of two types of compression bandage with different degrees of elasticity as regards subbandage pressure during rest and walking within the period until next application of the bandage. Since it has been suggested that an elastic bandage might compromise blood circulation during the night, a few nocturnal measurements of the subcutaneous blood flow and arterial pressure of the first toe have been performed in addition.

PATIENTS AND METHODS

Patients with venous leg ulcer and a systolic arterial pressure of first toe >60 mmHg were included in the study. After informed consent was obtained, they were randomized into treatment with either a long-stretch non-adhesive compression bandage (Setopress: Seton Health Care, Oldham, U.K.) or a short-stretch non-adhesive compression bandage (Comprilan: Beiersdorf, Hamburg, Germany). When stretched with a tension of 3 kg, Comprilan had a stretch capacity of 89% compared to the unstretched bandage, while Setopress had a stretch capacity of 209% (2).

The ulcer was covered with a local dressing, and the lower leg was padded with gauze in order to create a uniform surface. Both types of compression bandage were used in widths of 10 cm and applied using a spiral bandaging technique from toe to knee. With the foot in a 90° position, the bandage was applied around the foot, starting laterally at the base of the toes, then turning around the ankle and heal with returns to the foot enclosing the heel. The turns now continued up the leg in an ascending spiral with a 50% overlap to stop just below the knee. Usually, about one and a half lengths of the short-stretch bandage (a total length of about 4.5 m in the unstretched state) was necessary, the excess of bandage cut off, while usually one length of the long-stretch bandage (3.5 m unstretched) was sufficient. The extension used for both types of bandage aimed at obtaining a subbandage pressure of 40 mmHg in the dependent and upright positions 4 cm above the medial malleous, the pressure decreasing up the leg. The long-stretch bandage was stretched on the lower leg with a tension of approximately 1 kg (brown rectangles marked on the bandage become squares = 86% stretch), depending, however, on the diameter of the leg, the larger the diameter, the larger the tension, according to Laplace's equation: $P = TN \times 4630/CW$, where P = pressure (in mmHg), T = bandage tension (in kg), N = number of layers applied, C = circumference of the limb (in cm), W = bandage width (in cm) (3). Unchanged stretch together with increasing diameter secured a decreasing pressure up the leg. The stretch was diminished just below the knee. Slightly less extension was used on the foot, depending on the amount of oedema present. The short-stretch bandage was stretched using a tension comparable to that used for the long-stretch bandage. In a few cases, the patient could not tolerate the intended pressure initially, and the treatment was then initiated with a lower pressure.

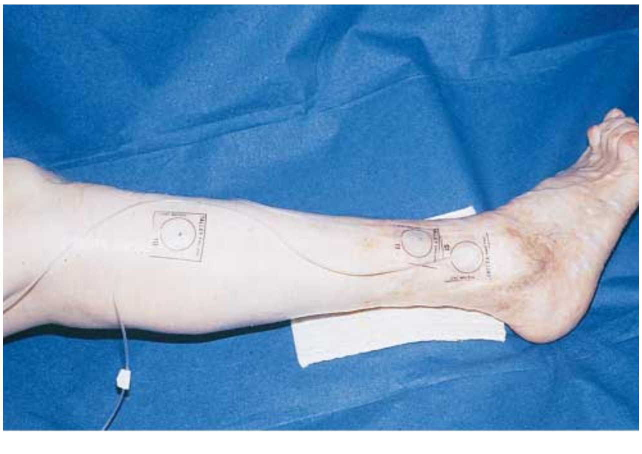

Fig. 1. Sensor cells taped to the skin of the leg (Danielsen L., Ugeskr Læger 1994; 156: 7562–7563).

 ISSN 0001-5555

Fig. 2. With the compression bandage applied, continuous scan is performed using the Oxford pressure monitor by Lene Henriksen (Danielsen L., Ugeskr Læger 1994; 156: 7562–7563).

The subbandage pressure was intended to be measured at regular intervals during the study period of up to 1 year. The subbandage pressures were measured with an Oxford pressure monitor (Talley, Romsey, Hants, U.K.) (Figs. 1 and 2) with six sensor cells connected, and the pressure was measured at three levels on the medial as well as on the lateral aspect of the lower leg (4 and 8 cm above the malleolus and at the level of widest circumference of the lower leg) with the patient in supine and upright positions as well as during walking and passive dependency. The sensor cells were made of PVC foil, each cell with a circular inflatable field, 2.5 cm in diameter. Before applying the bandage, the cells were taped to the skin in the standard positions (Fig. 1). The ulcer might, however, exclude the placing of one of the cells. The cells were connected to the monitor via plastic tubes. Continuous scan in turn through the six sensor cells was performed with approximately 10 cycles (Fig. 2). The readings, indicated as average, maximum and minimum values, were stored and later fed into a computer. After the scan, the tubes were disconnected, with the cells remaining in unchanged position beneath the bandage, and reconnected at later readings. The measurements were performed immediately after application of the bandage, and after 2 and 24 h, and in patients using the long-stretch bandage just before removal of the bandage. The long-stretch bandage was kept on as long as possible, varying from 1 to 7 days, depending on the amount of wound exudate. The short-stretch bandage was changed every day. Application of the bandage and the subbandage measurements were performed in all cases by one of the authors (LH).

In addition, lower extremity blood circulation during the night was monitored in three patients treated with the long-stretch bandage and in one patient with the short-stretch bandage. Xenon-133 was applied atraumatically and data on the washout from the resulting subcutaneous depot were recorded and processed as described previously (4, 5); at the same time, continuous measurement of systolic arterial pressure of the first toe was performed via Finapress (Ohmeda). One of the patients using the long-stretch bandage was examined twice using Xenon-133 washout.

Statistics

The distributions of individual subbandage pressures at a given time of measurement, and of differences between maximum and minimum subbandage pressures during walking, did not significantly differ from normal distribution and variances were equal, so the mean values were compared between the long- and short-stretch bandage groups by independent samples two-tailed *t*-test. The ratios between number of occurrences of a subbandage pressure between 35 mmHg and 45 mmHg vs. below or in excess of this interval were compared by Pearson chi-square test.

Ethics

The study was accepted by the Scientific Ethics Committee for the Municipalities of Copenhagen and Frederiksberg.

RESULTS

Of the allocated 43 leg ulcer patients, 23 were randomized to the long-stretch bandage and 20 to the short-stretch bandage.

Table I. *Subbandage pressure 4 cm above the medial malleolus*

Position	Time	*n*	Long stretch compression bandage mmHg mean ± SD	*n*	Short stretch compression bandage mmHg mean ± SD	*p*-value
Supine	0 hours	49	30.7 ± 9.9	41	28.8 ± 9.4	0.343
	2 hours	44	29.6 ± 9.4	38	22.6 ± 8.2	0.001
	24 hours	42	30.4 ± 8.9	36	19.0 ± 7.8	< 0.001
	2–6 days	28	32.9 ± 13.2			
	7 days	11	27.5 ± 7.5			
Dependent	0 hours	49	39.2 ± 14.6	41	35.8 ± 12.2	0.240
	2 hours	44	39.9 ± 13.2	38	30.9 ± 8.6	0.001
	24 hours	42	40.6 ± 12.5	36	25.9 ± 8.2	< 0.001
	2–6 days	28	41.8 ± 14.4			
	7 days	10	38.1 ± 6.8			
Upright	0 hours	49	39.1 ± 12.6	41	41.0 ± 15.4	0.522
	2 hours	44	38.9 ± 10.2	38	32.6 ± 11.3	0.010
	24 hours	42	40.4 ± 14.3	36	31.1 ± 19.2	0.017
	2–6 days	28	43.0 ± 19.6			
	7 days	10	39.5 ± 8.2			
Walking	0 hours	49	39.1 ± 13.7	38	37.8 ± 12.9	0.644
	2 hours	44	39.1 ± 11.7	35	31.3 ± 10.1	0.003
	24 hours	42	39.8 ± 13.3	33	26.8 ± 9.8	< 0.001
	2–6 days	28	41.6 ± 16.5			
	7 days	10	38.6 ± 9.0			

Table II. *Nocturnal blood flow in subcutaneous tissue*

	ml 100 g^{-1} min^{-1}		
	Start of night	Hyperaemic phase	Rest of night
Long stretch	4.6	7.5 (1.6)*	
compression	7.9	8.0 (1.0)	5.1
bandage	3.7	5.1 (1.4)	2.5
			3.1
Short stretch compression bandage		11.7	3.7

*Relative to reference level: start of the night.

The patient data and the healing pattern are described elsewhere (6). For various reasons the intended subbandage pressure measurements could not be carried out at regular intervals in all cases.

Subbandage pressure measurements 4 cm above the medial malleolus are given in Table I. The number of patients with the subbandage pressure obtained close to the intended 40 mmHg was evaluated as follows: at 24 h the subbandage pressure during dependency 4 cm above the medial malleolus in patients with the long-stretch bandage was ≥ 35 mmHg ≤ 45 mmHg in 35.7% of the examinations, >45 mmHg in 35.7% and <35 mmHg in 28.6%, while the corresponding figures in patients with short-stretch bandage were 16.7%, 2.8% and 80.6% ($p=0.00001$). The long-stretch bandage maintained a significantly higher subbandage pressure during supine and upright positions, during passive dependency and during walking in all medial and lateral locations than the short-stretch bandage after both 2 and 24 h. After 24 h the mean values at the widest circumference medially during upright position were 21.8 mmHg with the long-stretch bandage and 11.7 mmHg with the short-stretch bandage ($p<0.001$). The pressure was maintained by the long-stretch bandage during the period to next reapplication of the bandage. The difference between maximum and minimum subbandage pressures during walking was of the same size for both types of bandage ($p=0.730$ at 0 hours, $p=0.850$ at 2 h, $p=0.494$ at 24 h). Subbandage pressure in the supine position was generally lower than in the other positions for both types of bandage and equal for the two bandage types at 0 h. Pain from the sensor cells was not reported; in one case a vesicle was observed beneath a sensor cell.

The measurements of nocturnal Xenon-133 washout are given in Table II. Systolic arterial pressure of the first toe increased during the night for all three patients using long-stretch bandage, with values ranging from 3.2 to 9.2 mmHg per hour, while pressure for the patient who used the short-stretch bandage decreased by 9.7 mmHg per hour.

DISCUSSION

It was decided to change the long-stretch bandage as seldom as possible, since a few subbandage pressure measurements prior to study showed that this bandage was capable of maintaining the pressure throughout at least 5 days. The short-stretch bandage was changed every day, because subbandage pressure measurements with this bandage prior to the study indicated a pressure decrease within the first 24 h. The Oxford pressure monitor (Talley, Romsey, Hants, U.K.) was used for the subbandage pressure measurements since this has been reported to be more accurate over prolonged periods than a medical stocking tester (1, 7). In a study comparing different techniques for interface pressure measurement systems there was a large difference between them, with Talley instruments showing an acceptable reproducibility (8). Since in the present study the long-stretch bandage maintained a higher subbandage pressure in all positions of the leg than the short-stretch bandage after both 2 and 24 h, our results suggest a positive influence of the elasticity of a compression bandage on the capability of the bandage to maintain a high subbandage pressure. Furthermore, the pressure beneath the long-stretch bandage was maintained during the period until next bandage change, which could be up to 1 week. A pressure drop within the first 4 h has previously been observed underneath Comprilan, while elastic bandages maintained the pressure (9, 10). However, the capability to obtain a sufficiently high subbandage pressure initially probably varies among the different types of elastic bandages. A dauer type of non-adhesive elastic bandage, Wero Lastic, has been evaluated with a thin rubber balloon, 9 cm long and 1.7 cm wide, placed longitudinally during the bandaging on the lateral side of the calf where the circumference of the leg was 27 cm (11). The pressure beneath 2 layers of a 10 cm wide Wero Lastic with 80% stretch varied from 6 to 18 mmHg, with 4 layers from 17 to 28 mmHg.

It has been suggested that a short-stretch bandage will support the vein-muscle pump more effectively than a long-stretch bandage, since short-stretch bandages are believed to exert a high subbandage pressure during activity of the leg muscles and a low resting pressure, while on the other hand treatment with long-stretch bandages has been suggested to result in a smaller amplitude in pressure variations and less difference between activity and rest of the leg muscles (10). The present study, however, showed that the difference between the maximum and minimum subbandage pressures achieved during walking was of the same order for the two types of bandage. Thus the long-stretch bandage used in the present study appears to make the vein-muscle pump as effective as the short-stretch bandage.

Furthermore, it is suggested that a short-stretch bandage is safer to use during the night than a long-stretch bandage, because the subbandage pressure beneath the former decreases when the patient lies down and thus does not compromise the nocturnal blood flow (10). In the present study, the subbandage pressure decreased in the supine position for both types of bandage, the long-stretch bandage, however, performing a higher pressure in all positions of the leg than the short-stretch bandage. The long-stretch bandage appeared in the present study to increase the nocturnal systolic digital pressure, and the subcutaneous blood flow showed values during the night comparable to those of normal controls having no compression bandage on their leg (12). The present study thus appears to indicate that the long-stretch bandage can be used with safety during the night as long as a complicating arterial insufficiency can be ruled out. However, studies of a larger number of patients are needed before final evaluation of the nocturnal blood flow related to the long stretch compression bandage can be made.

ACKNOWLEDGEMENT

We express our gratitude to Coloplast A/S and Beiersdorf A/S for financial support.

REFERENCES

1. Blair SD, Wright DDI, Backhourse CM, Riddle E, McCollum CN. Sustained compression and healing of chronic venous ulcers. Br Med J 1988; 297: 1159–1161.
2. Nielsen JS. Coloplast A/S, Humlebæk, Denmark. Personal communication
3. Thomas S. Bandages and bandaging: the science behind the art. Care Sci Practice 1990; 8: 56–60.
4. Sindrup JH, Kastrup J, Jørgensen B, Bülow J, Lassen NA. Nocturnal variations in subcutaneous blood flow rate in lower leg of normal human subjects. Am J Physiol 1991; 260: 480–485.
5. Sejrsen P. The 133 Xenon washout technique for quantitative measurement of cutaneous and subcutaneous blood flow rates. In: Serup J, Jemec GBE. Handbook of non-invasive methods and the skin. Boca Raton: CRC Press, 1995: 429–436.
6. Danielsen L, Madsen SM, Henriksen L. Venous leg ulcer healing. A randomized prospective study of long stretch versus short stretch compression bandage. In manuscript
7. Robertson JC, Shah J, Amos H, Druett JE, Gisby J. An interface pressure sensor for routine clinical use. Eng Med 1980; 9: 151–156.
8. Allen V, Ryan DW, Lomax N, Murray A. Accuracy of interface pressure measurement systems. J Biomed Eng 1993; 15: 344–348.
9. Callam MJ, Haiart D, Farouk M, Brown D, Prescott RJ, Ruckley CV. Effect of time and posture on pressure profiles obtained by three different types of compression. Phlebology 1991; 6: 79–84.
10. Veraart JCJM, Neumann HAM. Interface pressure measurements underneath elastic and non-elastic bandages. Phlebology 1996; 11 Suppl 1: 2–5.
11. Hansson C, Swanbeck G. Regulating the pressure under compression bandages for venous leg ulcers. Acta Derm Venereol (Stockh) 1988; 68: 245–249.
12. Sindrup JH, Kastrup J, Kristensen JK. Diurnal variations in lower leg subcutaneous blood flow rate in patients with chronic venous leg ulcers. Br J Dermatol 1991; 125: 436–442.